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COMMISSIONING OF THE NEW LARGER-SCALE FLAMMABILITY APPARATUS FOR BRATTICE CLOTH

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MRL 89-31(TR)

March 1989

19 pp

MICROMEDIA

COMMISSIONING OF THE NEW LARGER-SCALE FLAMMABILITY APPARATUS FOR BRATTICE CLOTH

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ABSTRACT

A new apparatus to determine the flammability of brattice cloth, based on the Mine Safety and Health Administration's "standardized small-scale flammability tester" has been built as a replacement for the existing small-scale flame test used currently for certification of brattice cloth by EMR. Tests were carried out on four different materials for evaluation of the apparatus. Although some operator-to-operator variability was observed, the apparatus can distinguish well between fire-resistant and non fire-resistant materials. Therefore, it is recommended to the Canadian Standards Association for inclusion in their forthcoming standard for ventilation materials. A videotape of the tests was made.

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KEYWORDS: brattice cloth, ventilation materials, flammability

CONSTRUCTION D'UN NOUVEL APPAREIL PLUS GROS PERMETTANT DE DETERMINER L'INDICE D'INFLAMMABILITE DES TOILES D'AERAGE

par

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RESUME

Nous avons construit un nouvel appareil permettant de mesurer l'indice d'inflammabilité des toiles d'aérage; ce nouvel appareil, qui est basé sur "le petit appareil de mesure de l'inflammabilité normalisé" par la *Mine Safety and Health Administration* des Etats-Unis, remplacera le petit appareil actuellement utilisé par Energie, Mines et Ressources Canada pour la certification des toiles d'aérage. Nous avons effectué des essais avec quatre matériaux différents en vue d'évaluer l'appareil. Les resultats variaient quelque peu d'un opérateur à l'autre, mais l'appareil permettait de distinguer facilement les matériaux résistants au feu des matériaux non résistants. Nous recommandons donc que la norme de l'Association canadienne de normalisation visant les matériaux d'aérage, présentement en cours de préparation, prévoit l'utilisation de cet appareil. Les essais ont été enregistrés sur bande vidéo.

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MOTS CLE: toile d'aérage, matériaux s'aérage, inflammabilité

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INTRODUCTION

A fire in an underground mine can be a very dangerous occurence because of limited means of escape. Ventilation tubing and brattice cloth are often made of polymeric materials, which are potential sources of spreading a fire once ignited. Therefore, the use of fire-retardant materials is often required.

In 1970, an evaluation of different flammability methods was carried out in this laboratory in order to determine the best method to adopt for certifying fire-resistant ventilation tubing (1). The outcome of this study was to adopt the National Coal Board (NCB) Specification 245/1961 (2). In this test, a sample 2 in. X 14 in. is exposed to a Barthel burner for 20 s; criteria are applied to the time and extent of burning after the flame is removed. Even at that time, it was noted that the sample could curl away from the burner flame, resulting in reducing the flame persistence time (1). The NCB later amended 245/1961 to require that materials be subjected to a weaker flame in addition to the Barthel burner, because "it was found that certain types of these materials are able to pass the Barthel flame test but burn readily when exposed to a weaker flame test" (3). The NCB is reported to unofficially use a test, wherein the flame is kept in contact with the sample by following it up as it shrinks (4).

The U.S. Bureau of Mines carried out, in 1972, large-scale fire tests on brattice cloths, comparing the results to the ASTM E-162 Standard, which was the required test at that time. Their conclusion was that a flame spread index of 25 or less as determined in ASTM E-162 provided assurance that the brattice cloth was reasonably fire-resistant. Later work by MSHA found that some materials which had flame spread indices below 25 were still

flammable and that E-162 yielded variable, operator-dependent data (5). A new, large-scale test was developed in 1980 by the U.S. Bureau of Mines and U.S. Mine Safety and Health Administration (MSHA), which tested the materials in similar conditions as they are used. For practicality, MSHA later (in 1983) determined the smallest size of gallery that would correlate with the large-scale test. This later became the "standardized small-scale flammability test", which is in current use for both brattice cloth (6) and rigid tubing (7). A similar apparatus built and used by the U.S. Bureau of Mines yielded good correlation with the MSHA apparatus (5).

In 1985, CEAL adopted an interim large-scale test for flexible materials that shrink away from the burner in the NCB small-scale test and for all rigid ducting. The existing propane gallery facility used for testing the flammability of conveyor belting was put into service for this interim test on ventilation materials. Because the ventilation through this gallery is fixed at 1.5 m/s, the interim test is probably somewhat less severe than the MSHA test (which operates at 0 and 0.65 m/s). Nevertheless, it provided a significantly more stringent test than the existing NCB test and prevents at least some *false passes*. CEAL's intention was always to replace the interim large-scale test by a Canadian Standard test, once one was adopted.

The Canadian Standards Association (CSA), through its Technical Committee M427, is currently in the process of developing a standard to cover flammability and antistatic requirements for ventilation materials used in underground mines. At its last meeting in October 1987, the Committee decided that the flammability tester used by the U.S.A. MSHA should be adopted for assessing the flammability of ventilation materials that will be installed in non-vertical shaft applications. In order to distinguish it

from true small-scale tests, such as the NCB test, the committee has named it the **horizontal flammability test**. For vertical shafts, which are a more critical application, the Committee is requiring that a more severe test be used in addition to the MSHA test, perhaps similar to the one developed by the U.S. Bureau of Mines (9). Because the latter will require more development work, the Committee decided that the first edition of the Standard would not cover the requirements for vertical shafts.

In anticipation of the Standard, a copy of the MSHA apparatus was ordered constructed by the Technical Services Division of CANMET. This report describes a series of tests carried out using this apparatus.

APPARATUS

The main part of the horizontal flammability apparatus is almost identical to that of MSHA; their drawing is shown in Fig. 1 with the exception that an axial flow fan (Canadian Blower/Canada Pump Inc. size 18 type LB tube) was installed in place of a shaded-pole fan (Dayton model 2C995). The former allows a much better range of adjustment of its speed. The fan is controlled by a Boston Gear Ratiopax DC motor control. In addition, Fiberfrax Duraboard LD was used in place of Marinite, in order to avoid the use of asbestos. The apparatus was attached to a steel table 92 cm wide, 90 cm high and 295 cm long, with casters for mobility.

A Solarflo impinged jet burner No. U-10, fed by technical grade methane, was used as the ignition source. The burner is identical to the one used by MSHA. MSHA uses local natural gas (Dallas Pike), which contains 97% methane. The difference in fuel should have virtually no effect on the flame intensity.

A dedicated room has not yet been constructed for this apparatus. As a temporary measure, the apparatus was placed pointing into the existing fume hood in the main laboratory of CEAL. Plastic sheeting was used to block off the remaining opening of the fume hood to increase the efficiency of fume removal. Due to the limitations of the exhaust capacity of the fume hood fan and to prevent excess fumes from entering the laboratory, the velocity range of the apparatus was limited to between 0.4 and 1.3 m/s.

EXPERIMENTS

Samples of four different ventilation materials were available for testing. Sample #1 was a non fire-resistant polyethylene, sample #2 was similar to sample #1, but with fire-retardants added, samples #3 and #4 were fire-resistant PVC products.

The results of all the 25 trials are shown in Table 1. The order of the tests is given by the "trial no."; in order to show the effect of the various factors, the trials are not presented in chronological order. The tests were videotaped: the unedited tape runs about two hours. An edited version showing only the highlights was made; it runs about eight minutes.

The ignitor time refers to the time that the burner was placed in contact with the material. Notice that the asterisked times refer to those trials in which the material shrank up to the holder and the ignition had to be terminated early. Although the standard time that MSHA applies the burner to brattice cloth samples is 25 s, another criterion is applied to materials that shrink rapidly away from the burner: the burner is removed after 300 mm of material in the horizontal direction is consumed completely. The "cloth burning" refers to the time that a flame remained visible on the cloth after

the burner was removed. The "floor burning" refers to the total time that material, that had fallen on the floor, was burning. It differs from the MSHA definition which counts only floor burning **after** the flame on the cloth has extinguished **plus** floor burning during application of the burner. For samples that burnt to the end, the cloth burning and the floor burning times (double asterisks) refer to the times until the flames reach the end of the sample. The burning fragments were then put out with a Carbon dioxide fire extinguisher.

For sample #1, three operators each carried out the test twice, in order to estimate sample-to-sample and operator-to-operator reproducibility (the first six trials). These tests were all carried out at the standard air velocity (0.65 m/s). Once the cloth ignited, the material melted and dripped onto the floor. The drops of molten material burnt while dripping, creating a rather dramatic fire. The pools of molten material continued to burn until all the pool was consumed (or it was extinguished by the operator).

As can be seen from the cloth and floor burning times, the difference between operators is much greater than between different trials with the same operator. The difference appears to be how close the flame is held to the bottom of the shrinking material. The visual intensity of the floor burning was greater for operator #3 than for operator #2, which was in turn greater than for operator #1, which is in inverse order from the burning times, which is logical. (Recall that the burning times were the times that it took for the flames to spread to the end of the sample.)

The effect of velocity is substantial (compare trials #3, #6, #13 and #14). At the highest velocity, the flames on the cloth were blown out before reaching the end, but the pool of liquid on the floor continued to burn for some time. At the lowest velocity, the material burned much more

rapidly, as shown by the ignitor time and the two burning times.

The effect of ignitor time is shown by trials #3, #6, #17 and #18. There is some change between an ignitor time of 13 s and 5 s, but a drastic change between 5 s and 2 s. There would appear to be a critical ignitor time (or, equivalently, ignition energy) which must be supplied for the fire to become self-propagating.

The effect of the operator can be seen even more dramatically on sample #2. In all the tests on sample #2, the flames eventually went out by themselves. (In the apparent exception of trial #16, only a very small flame persisted, which clearly would have eventually self-extinguished.) In the tests conducted by operators #2 and #3, the burning times far exceeded the MSHA limit of one minute (average). In contrast, in both tests conducted by operator #1, the flames went out almost immediately. It should be noted that on one of the tests conducted by operator #2, the flames almost went out after the burner was withdrawn, but then the fire grew rapidly.

The effect of velocity on the burning of sample #2 is similar to that of sample #1. More material was consumed at lower velocities. At the highest velocity, very little floor burning occurred.

The burner time did not have to be reduced very much in the case of sample #2 in order to virtually eliminate the burning times.

The variability amongst the operators was much less for sample #3. Indeed, operator #3, who was the most severe for samples #1 and #2, was the least severe for sample #3. Decreasing the velocity did increase the cloth burning time, but not substantially. The pools of liquid that dropped from the cloth self-extinguished quickly in all the trials of sample #3. Although the burning times and extent of burning was much smaller for sample #3 than #1 and #2, the smoke generated was much more noxious.

Sample #4 was similar to sample #3 in having short flameout times on the cloth. The molten material dripping from the cloth went out even quicker than sample #3. Even so, the smoke generated was blacker and more noxious than for sample #2.

DISCUSSION

The temporary set-up for the horizontal flammability tester was unsatisfactory for several reasons. The range of velocities was insufficient to provide complete testing. It is important, in particular, to be able to test at zero air velocity. According to MSHA (5), tests on light materials are more severe when carried out at zero air velocity. Our results tend to confirm this. Even with the fume hood fan on, noxious fumes escaped from the front of the apparatus. The people carrying out the tests had to wear gas masks for samples #3 and #4, and the laboratory had to be extensively aired out before re-entering. Physically, the large size of the equipment blocks the laboratory, making it inconvenient or impossible for other work to be carried out. The only solution is a separate room, preferably with the exhaust of the equipment vented directly outside through a roof stack. The room should have a separate exhaust that can draw off the fumes emitted from the front of the apparatus without affecting the airflow through the apparatus.

All four samples passed the small-scale NCB test. Sample #1 failed the interim flammability test; the others passed it. The reason why sample #2 passed the interim test yet failed the horizontal flammability test is the high velocity used in the interim test.

Unfortunately, the tests reported here indicate that, at least for

some samples, the operator has a substantial effect on the results. This occurs because the operator is required to follow the material as it shrinks. This variability problem probably will be of most importance with marginally-acceptable products. Perhaps operators can be trained to yield more reproducible results. Alternatively, an electrically operated holder for the burner capable of moving it in two directions (upwards and inwards) could be constructed and operated by a joystick. The operator could then be located outside the room. An additional benefit of this method would be the reduction of the turbulence caused by the operator being in front of the apparatus. If the projected work does not justify development of such equipment, it would be safest to use two different operators for marginal products.

A problem with testing light materials is their tendency to oscillate in the air stream. At one point, MSHA used small weights attached to the hanging cloth to prevent this oscillation, but found that this caused more variability and now test without the weights (5). Although the oscillation is quite annoying to the operator, its actual effect on the results is probably less than operator-to-operator variability.

The variability problems with the MSHA test would make it inappropriate for use as a flammability index tester. On the other hand, it is suitable as a go/no-go test. There will be a *grey area* in which products may pass or fail depending on the operator. The question that must be answered is how important is this grey area. The test will clearly fail materials, even light ones, which are not fire-resistant, which small-scale tests will not do. The test will also clearly pass highly fire-resistant materials. Borderline materials will yield irregular results. The manufacturer will have some risk of a *false failure*, but only of a material

that is close to the pass/fail boundary. It seems unlikely that there could be a *false pass* which would be a more serious occurrence. Improvements on the apparatus could be developed to reduce the grey area, e.g., making the flow of air through the chamber more laminar, using remote-control for the application of the burner to the material. These changes would add substantially to the cost of the apparatus.

As MSHA has indicated (5), and seen clearly on our videotape, the pools of burning liquid are at least as great a source of spreading the fire as are the actual flames on the brattice cloth. The CSA M427 Technical Committee will have to decide whether to adopt the total burning time minus overlap as in the MSHA criterion or adopt separate limits on the cloth and floor burning times.

CONCLUSIONS

The horizontal flammability test is a substantial improvement over the NCB small-scale test in evaluating the flammability behaviour of brattice cloth under reasonably realistic conditions and therefore is recommended for adoption by the CSA M427 Technical Committee. This Committee will have to decide whether a product such as sample #2, which produces a substantial fire, yet does not propagate the fire a significant distance, is acceptable. A separate room to accommodate the apparatus is required to be constructed before the test is implemented.

ACKNOWLEDGEMENTS

One of us (KJM) would like to express his appreciation for useful discussions with Mr. William Hoffman of the U.S.A. Mine Safety and Health Administration in Triadelphia, W. Va., on his visit there on May 7 - 8, 1985. The supply of test material from the manufacturers is also gratefully acknowledged.

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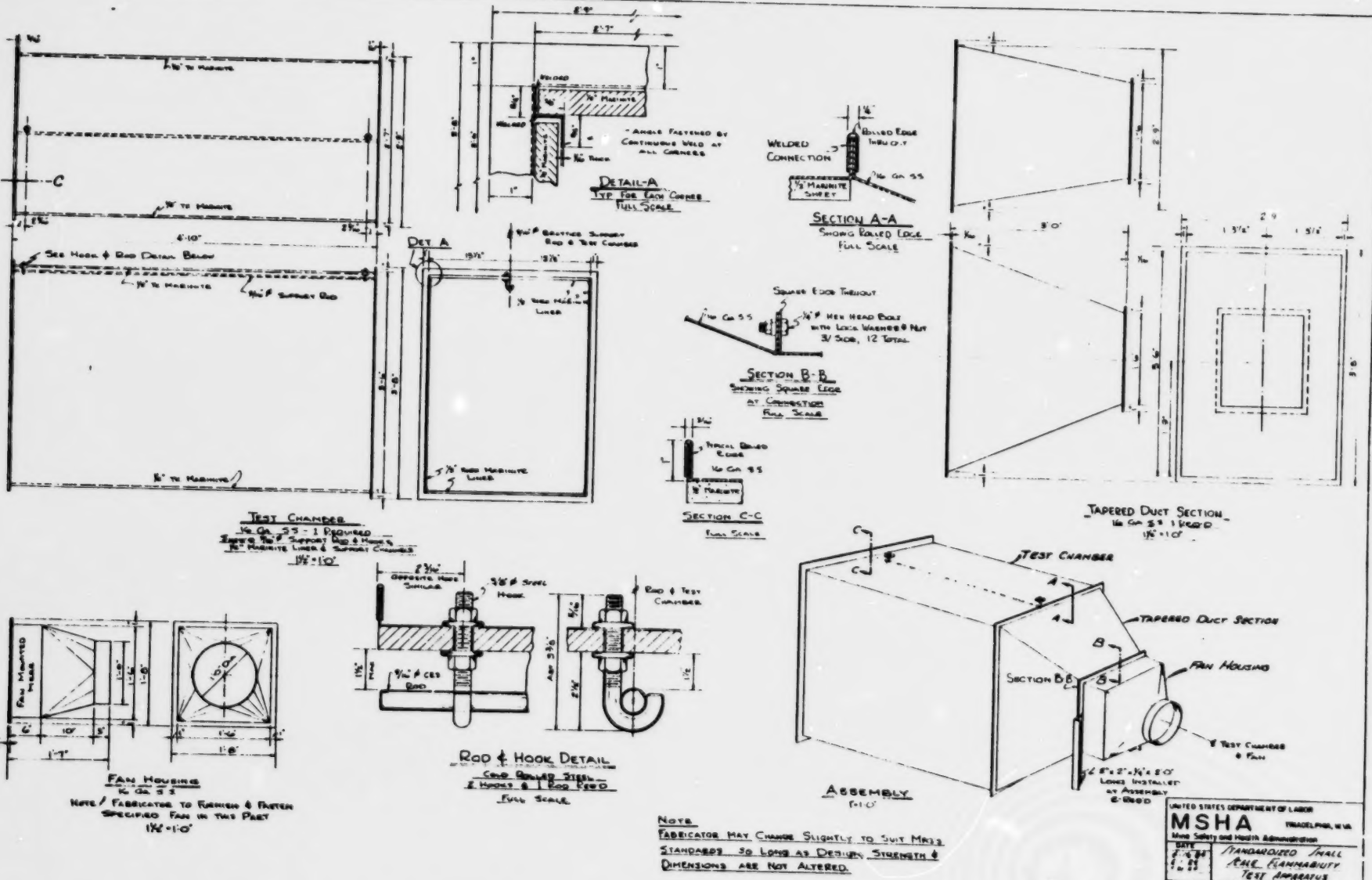
Table 1. Results of flammability tests on brattice cloth

trial	operator	air velocity (m/s)	ignitor time (s)	cloth burning (min:s)	floor burning (min:s)	length consumed (cm)
			Sample #1			
1	1	0.65	11*	6:48**	6:30**	to end
4	1	0.65	13*	5:03**	4:28**	to end
2	2	0.65	14*	4:20**	4:09**	to end
5	2	0.65	13*	4:12**	3:57**	to end
3	3	0.65	14*	2:14**	1:56**	to end
6	3	0.65	13*	2:07**	2:04**	to end
13	3	1.3	12*	5:11	8:03	74
14	3	0.4	7*	1:44**	1:46**	to end
17	3	0.65	5	4:50**	4:36**	to end
18	3	0.65	2	0:01	0:00	36
			Sample #2			
7	1	0.65	11*	0:00	0:00	70
10	1	0.65	10*	0:01	0:00	56
8	2	0.65	10*	9:44	5:28	67
11	2	0.65	8*	4:02	9:34	83
9	3	0.65	11*	9:23	10:46	74
12	3	0.65	7*	7:53	15:12	67
15	3	0.4	7*	5:20	4:01	71
16	3	1.3	12*	9:25**	0:03	60
19	3	0.65	5	0:03	0:03	46

Table 1. Results of flammability tests on brattice cloth (cont'd)

trial	operator	air velocity (m/s)	ignitor time (s)	cloth burning (min:s)	floor burning (min:s)	length consumed (cm)
			Sample #3			
20	1	0.65	20*	0:08	0:03	51
21	2	0.55	16*	0:16	0:05	51
22	3	0.65	19*	0:03	0:00	41
23	1	0.35	20*	0:20	0:03	59
			Sample #4			
24	1	0.65	25	0:08	0:00	66
25	2	0.65	25	0:21	0:00	56

* Burning time until the flames reached the end of the sample.
** Material shrank up to holder


C
C
DET A
DETAIL-A
TYP FOR EACH CORNER
FULL SCALE
SECTION A-A
SHOWING ROLLED EDGE
FULL SCALE
SECTION B-B
SHOWING SQUARE EDGE
AT CONNECTION
FULL SCALE
SECTION C-C
FULL SCALE
TEST CHAMBER
TAPERED DUCT SECTION
FAN HOUSING
SECTION B-B
ASSEMBLY
ROD & HOOK DETAIL
FAN HOUSING
TAPERED DUCT SECTION
1/4" = 1'-0"
NOTE
FABRICATOR MAY CHANGE SLIGHTLY TO SUIT MFGS
STANDARDS SO LONG AS DESIGN STRENGTH &
DIMENSIONS ARE NOT ALTERED.
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C-2258